Przegląd 2

Modelowanie fizyczne w animacji komputerowej

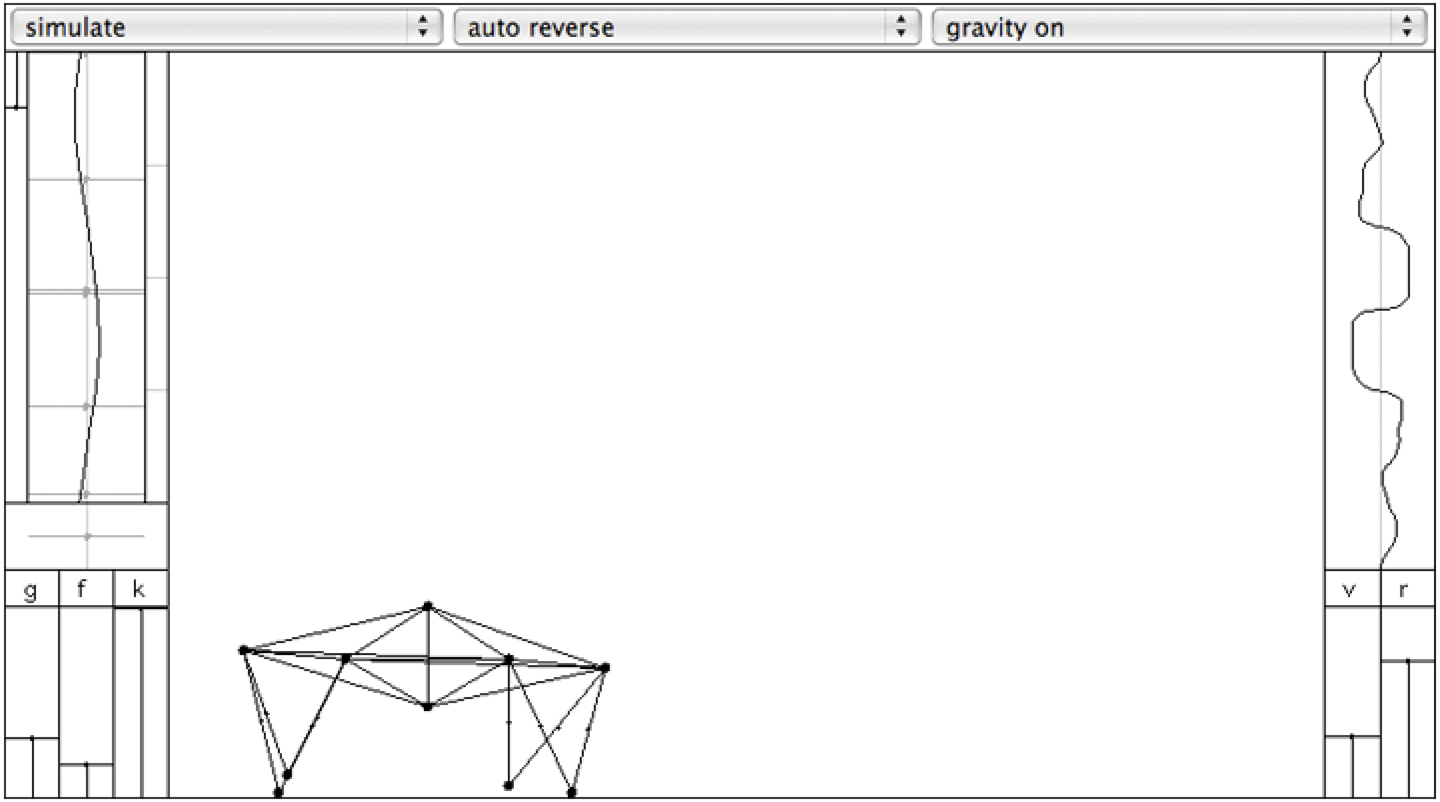
Maciej Matyka
http://panoramix.ift.uni.wroc.pl/~maq/

Wykład z Modelowania - przegląd

1 Aplikacje Spring-Mass
2 Model oceanu
3 Model granulatu
4 Model płynu MAC

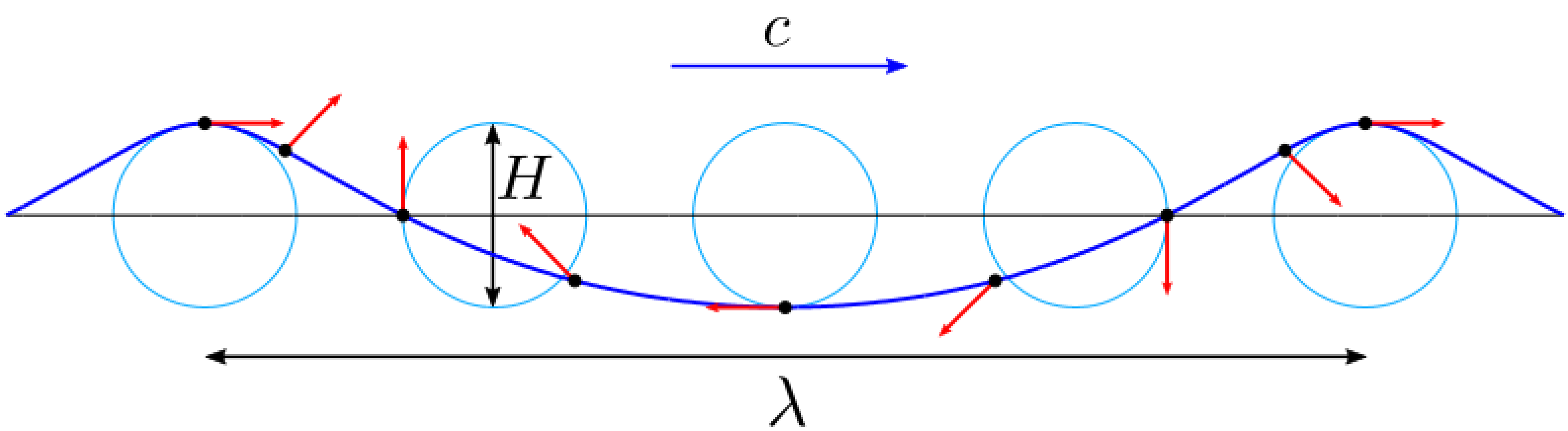
Aplikacje Spring-Mass

- Soda Play



Model Oceanu

Ruchy kołowe na powierzchni



H – amplituda
λ – długość fali
c – prędkość fazowa

Alain Fournier, William T. Reeves, A simple model of ocean waves, SIGGRAPH 86'

https://en.wikipedia.org/wiki/Trochoidal_wave

Spektrum energetyczne fal oceanu

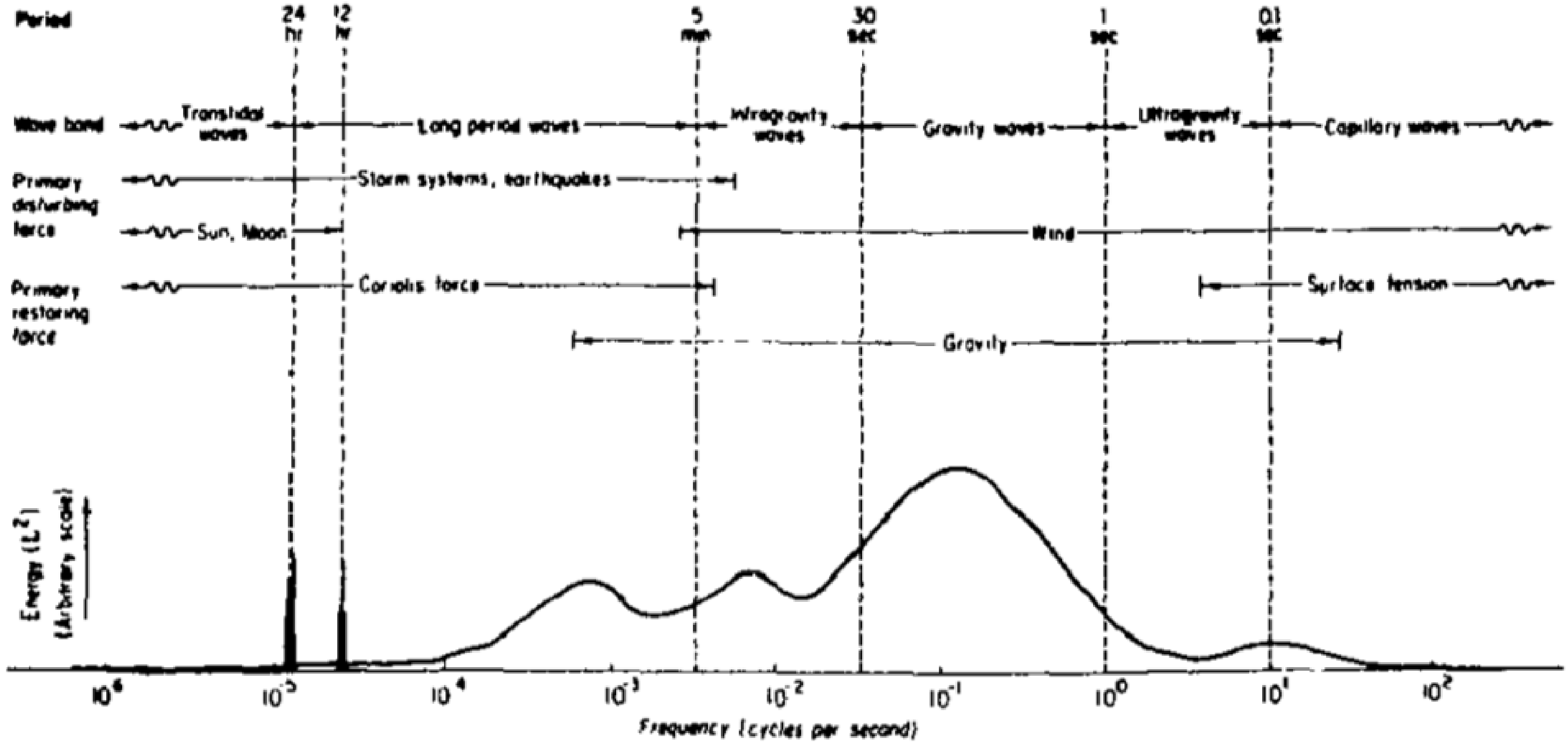


Figure 1
Rough energy spectrum of the sea (from [Kins84]).

Alain Fournier, William T. Reeves, A simple model of ocean waves, SIGGRAPH 86'

https://en.wikipedia.org/wiki/Trochoidal_wave

Załamania fal

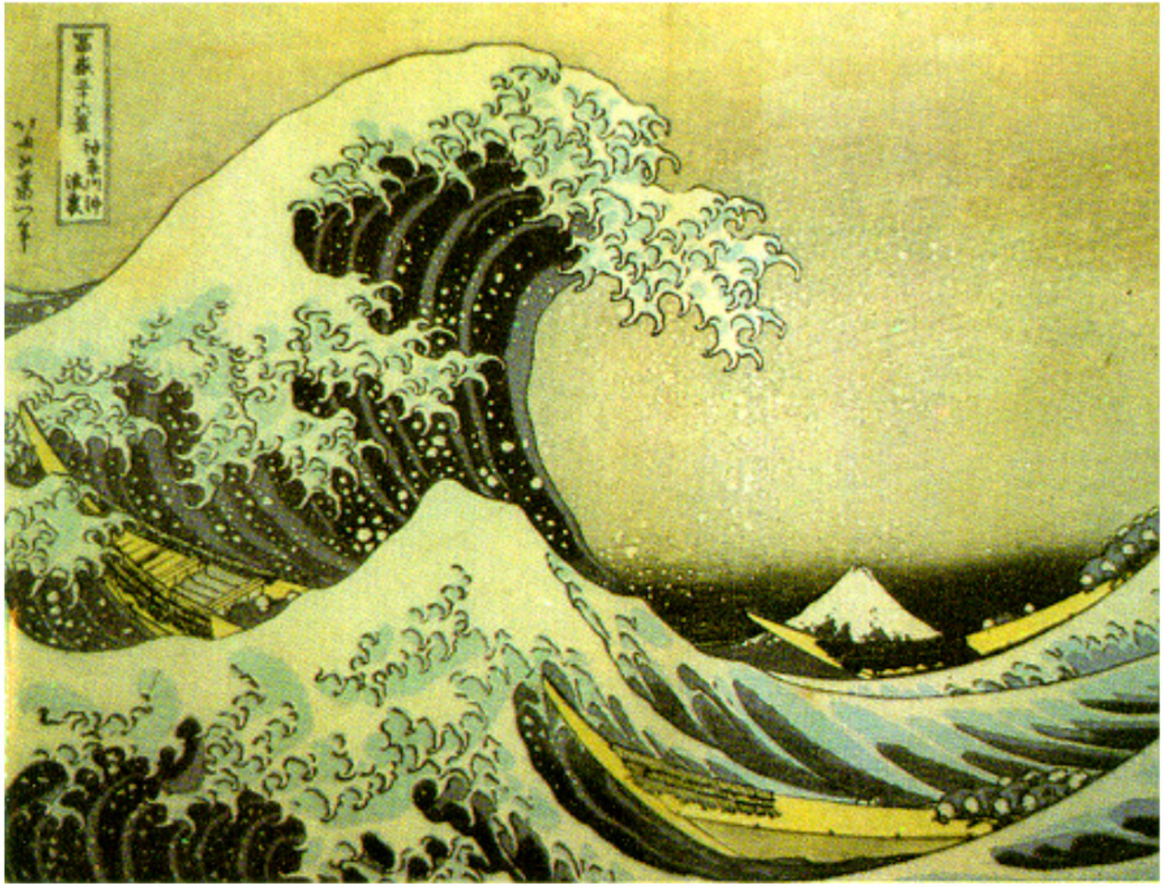


Figure 2
The surface of the sea is not a height field.

Alain Fournier, William T. Reeves, A simple model of ocean waves, SIGGRAPH 86'

https://en.wikipedia.org/wiki/Trochoidal_wave

Łamanie się fal

$$x = x_0 + r \times \cos\alpha \times S_x \times \sin\phi + \sin\alpha \times S_z \times \cos\phi$$

$$z = z_0 - r \times \cos\alpha \times S_z \times \cos\phi + \sin\alpha \times S_x \times \sin\phi$$

$$S_x = \frac{1}{1 - e^{-\kappa_x h}} \quad \text{and} \quad S_z = S_x(1 - e^{-\kappa_z h}$$

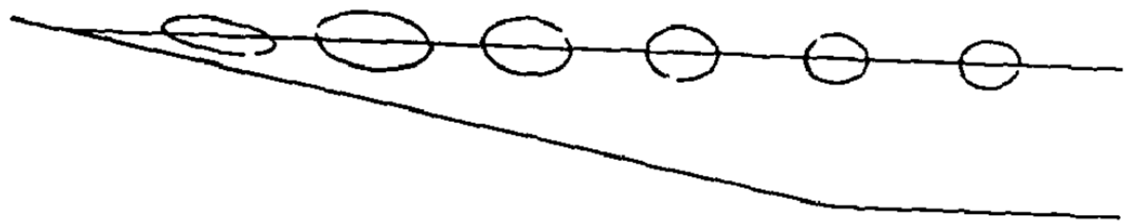


Figure 9
How the depth affects the orbits.
Gaps represent points at the same time.

Skalowanie orbit →

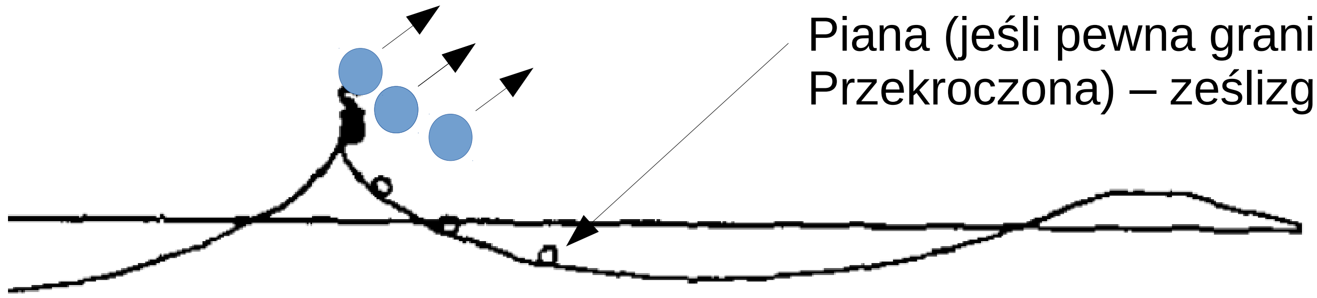
Figure 10
How the depth affects the shape of the waves.

Alain Fournier, William T. Reeves, A simple model of ocean waves, SIGGRAPH 86'

Łamanie się fal

Generowanie rozbryzgu jeśli różnica między prędkością punktu na powierzchni, a prędkością powierzchni (wzdłuż normalnej).

Rendering i zachowanie rozbryzgu → system cząsteczkowy.



Piana (jeśli pewna graniczna prędkość nie jest Przekroczona) – ześlizgiwanie po fali

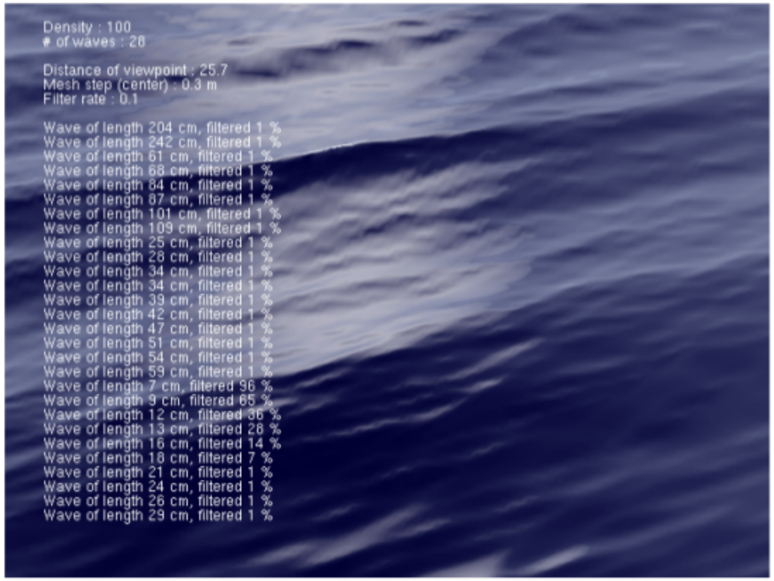
Alain Fournier, William T. Reeves, A simple model of ocean waves, SIGGRAPH 86'

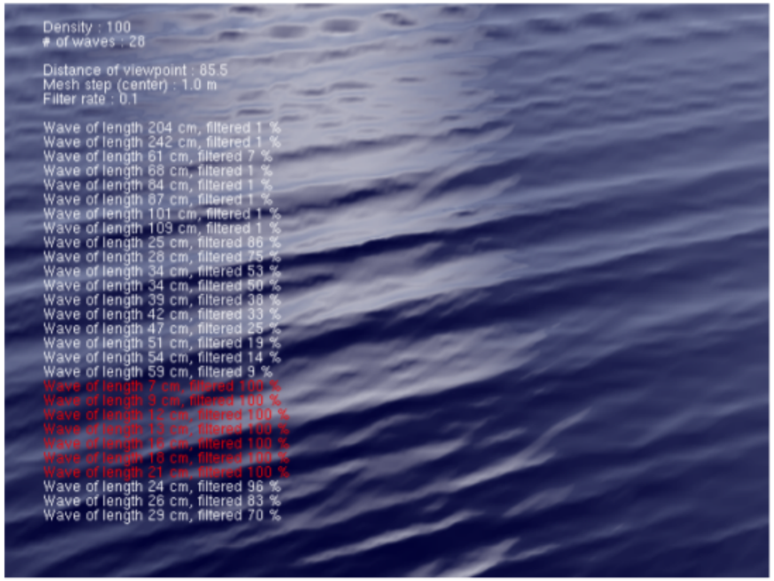
Ocean

Figure 16
Beneath the Waves of San Rafael

Alain Fournier, William T. Reeves, A simple model of ocean waves, SIGGRAPH 86'

Wykład z Modelowania - przegląd



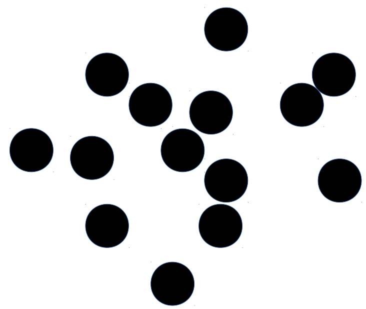


Model oceanu

(Reeves i in.)

Granulaty

Granulaty



– ziarna sferyczne
- siły oddziaływania (ziarno-ziarno)
- kolizje
- tarcie statyczne

Bell, N., Yu, Y. and Mucha, P.J. 'Particle-Based Simulation of Granular Materials', Eurographics/ACM SIGGRAPH (2005)

Granulaty

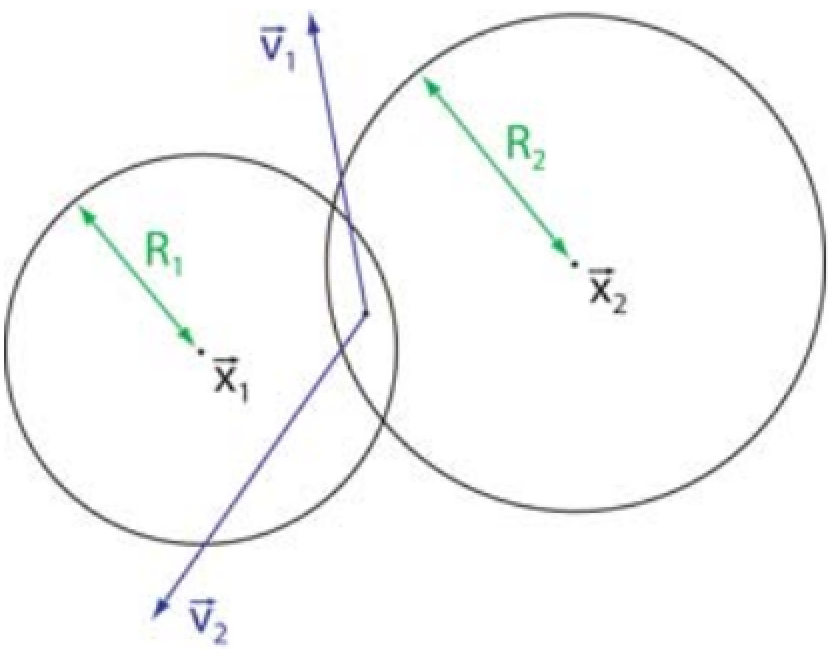


Figure 2: *Quantities used in collision modeling.*

Bell, N., Yu, Y. and Mucha, P.J. 'Particle-Based Simulation of Granular Materials', Eurographics/ACM SIGGRAPH (2005)

Granulaty

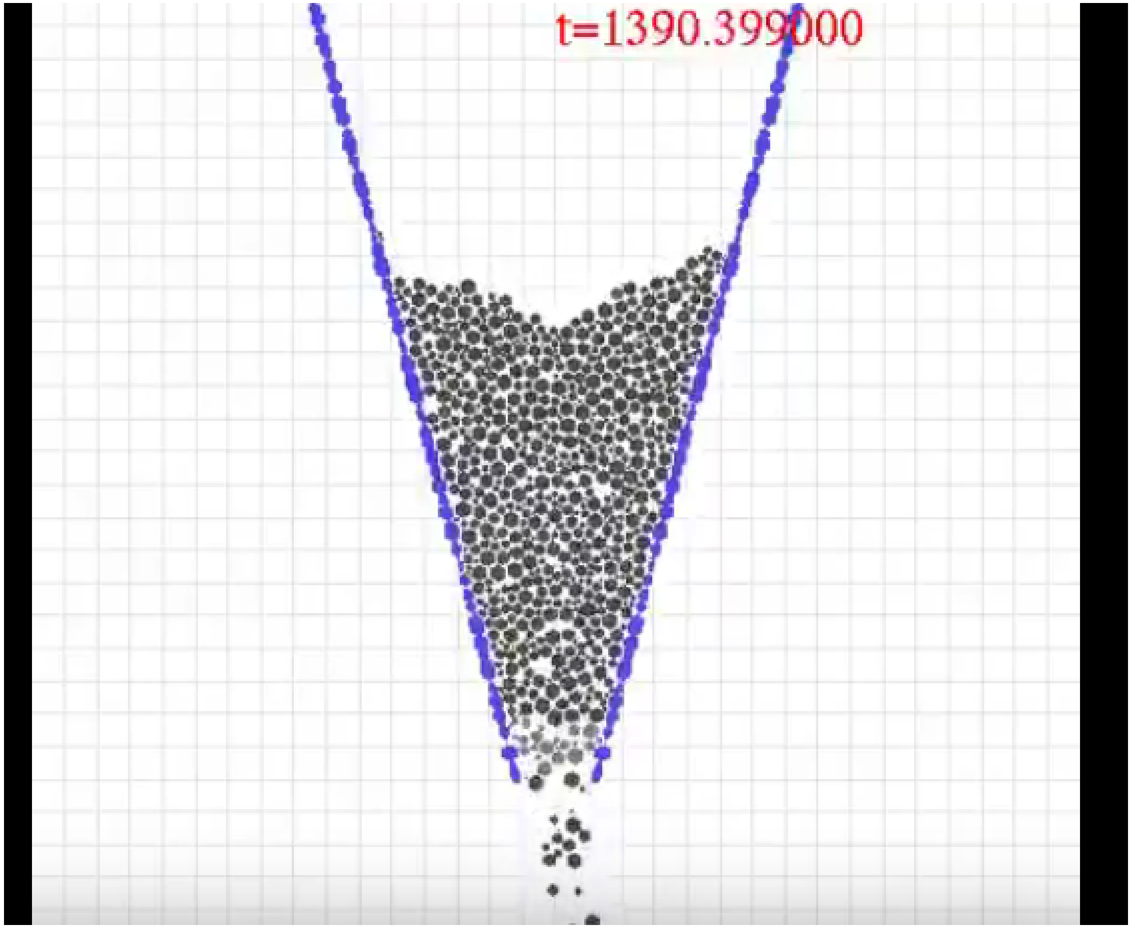
$$\xi = \max(\, 0,\ R_1 + R_2 - \|\vec{x}_2 - \vec{x}_1\|) \,,$$

$$\overrightarrow{N} = \frac{x_2 - x_1}{\|x_2 - x_1\|} \,.$$

$$\overrightarrow{F}_n = f_n \overrightarrow{N} \,,$$

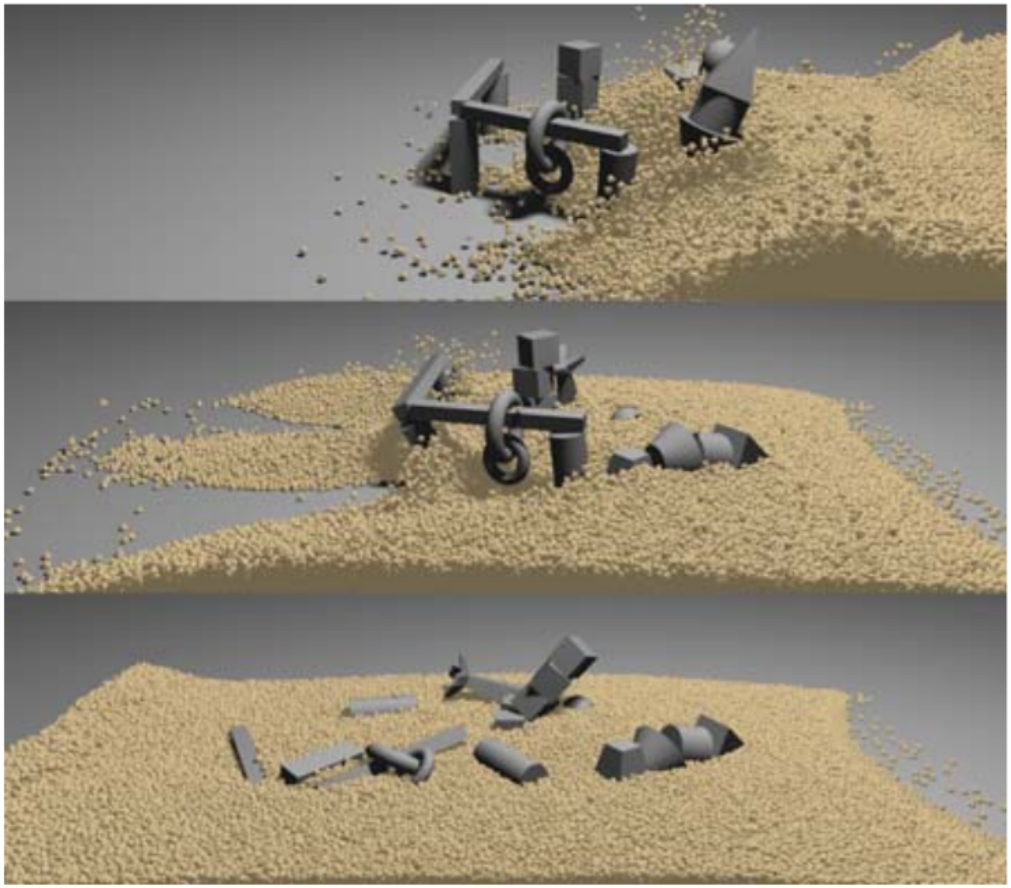
Siły **normalne + styczne** (detale w artykule)

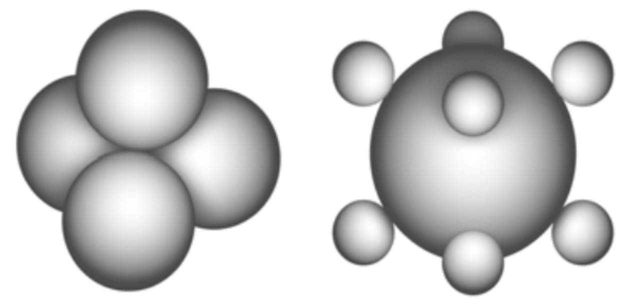
Bell, N., Yu, Y. and Mucha, P.J. 'Particle-Based Simulation of Granular Materials', Eurographics/ACM SIGGRAPH (2005)



Ristow, G. H., Herrmann, H. J., **'Density patterns in two-dimensional hoppers'** Phys. Rev. E 50(1), 1994

Granulaty

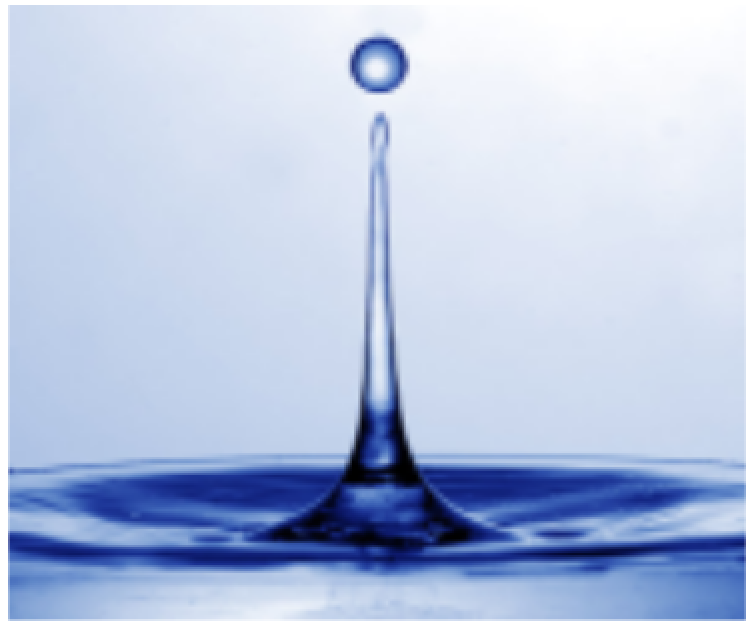




Bell, N., Yu, Y. and Mucha, P.J. 'Particle-Based Simulation of Granular Materials', Eurographics/ACM SIGGRAPH (2005)

Symulacje dynamiki płynów MAC

Wykład z Modelowania - przegląd



Symulacje dynamiki płynów
MAC

The Splash of Liquid drop (MAC)

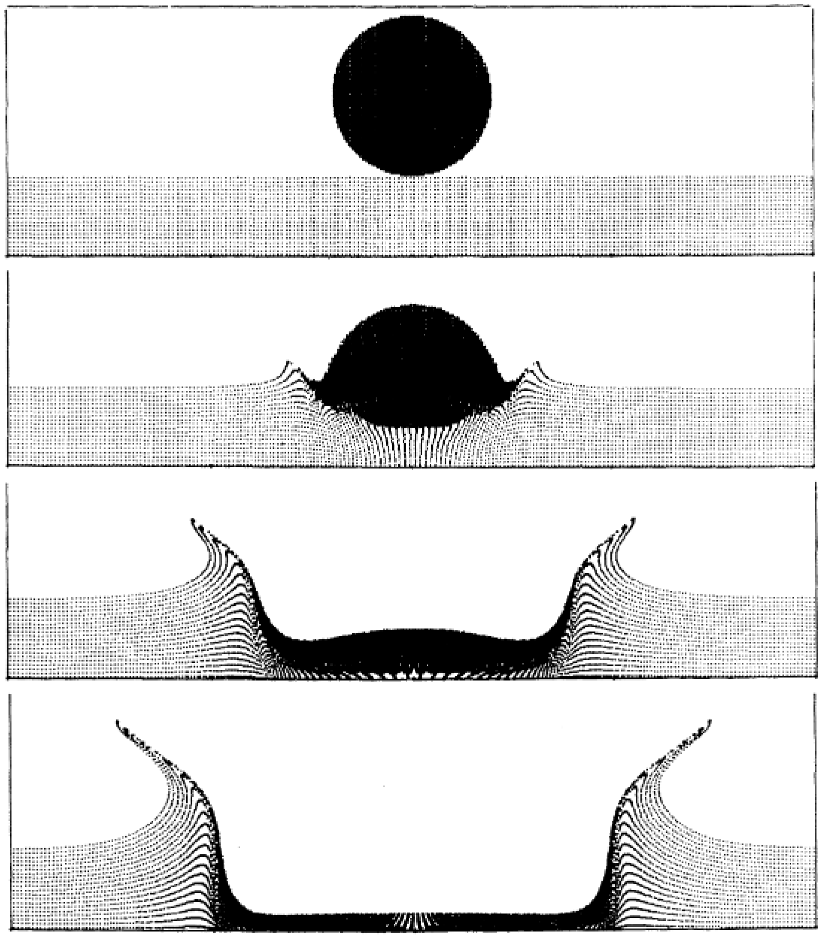


Fig. 5. Shallow-pool splash of a drop of radius 10.0 and impact speed 1.0; $R/D=1.0$. The frames are at times $t=0$, 10, 30, 50.

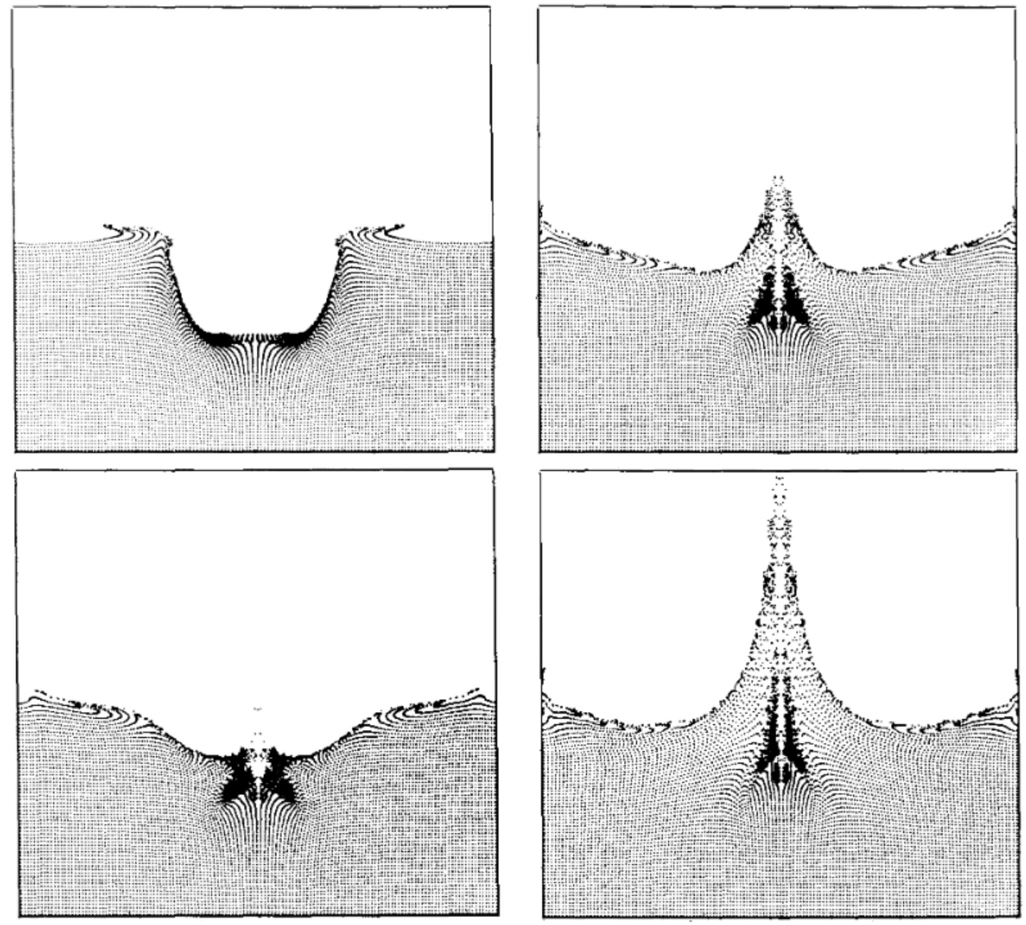


Fig. 13. Deep-pool splash of a drop of radius 5.0 and impact speed 4.0, with $(gR)^{1/2}/u_0=0.177$. The frames are at times $t=10$, 20, 25, 35.

Harlow, F., Shannon, J. P., Journal of Applied Physics 38 , 3855 (1967); doi: 10.1063/1.1709031

THE PHYSICS OF FLUIDS VOLUME 8, NUMBER 12 DECEMBER 1965

Numerical Calculation of Time-Dependent Viscous Incompressible Flow of Fluid with Free Surface

Francis H. Harlow and J. Eddie Welch
Los Alamos Scientific Laboratory, University of California, Los Alamos, New Mexico
(Received 16 April 1965; final manuscript received 3 September 1965)

A new technique is described for the numerical investigation of the time-dependent flow of an incompressible fluid, the boundary of which is partially confined and partially free. The full Navier–Stokes equations are written in finite-difference form, and the solution is accomplished by finite-time-step advancement. The primary dependent variables are the pressure and the velocity components. Also used is a set of marker particles which move with the fluid. The technique is called the marker and cell method. Some examples of the application of this method are presented. All nonlinear effects are completely included, and the transient aspects can be computed for as much elapsed time as desired.

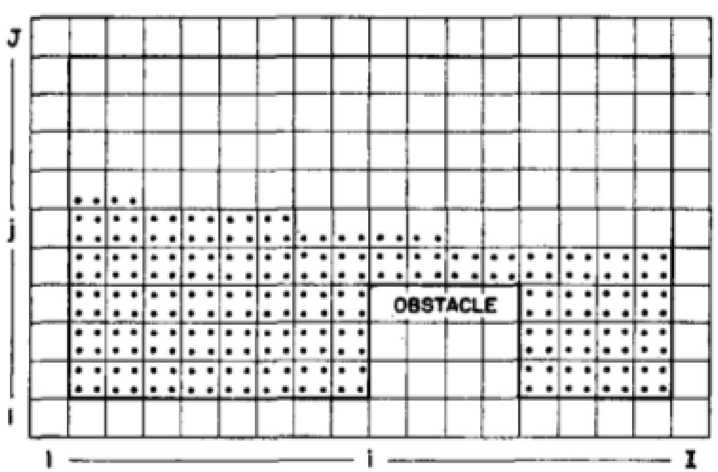


Fig. 1. Sketch of typical mesh and marker-particle layout. An actual calculation would be much more finely resolved.

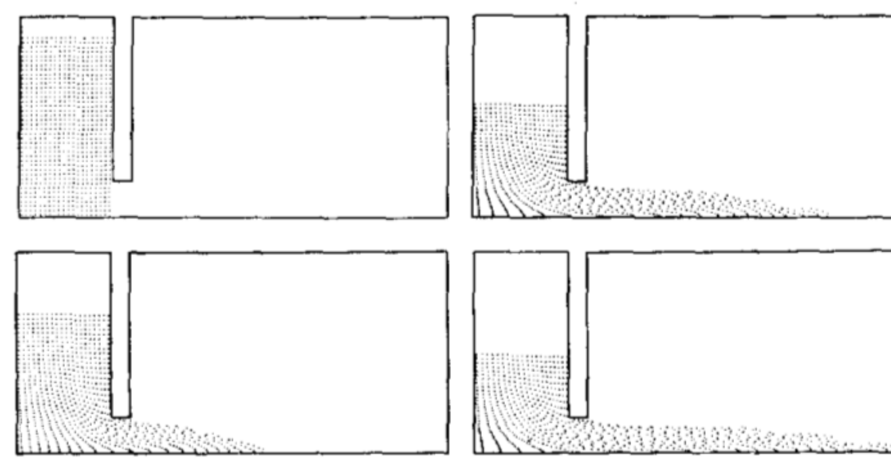


Fig. 6. Configuration of marker particles for the opening sluice gate at times $t = 0, 1.0, 1.5, 1.8$. The grid of computing cells is not shown.

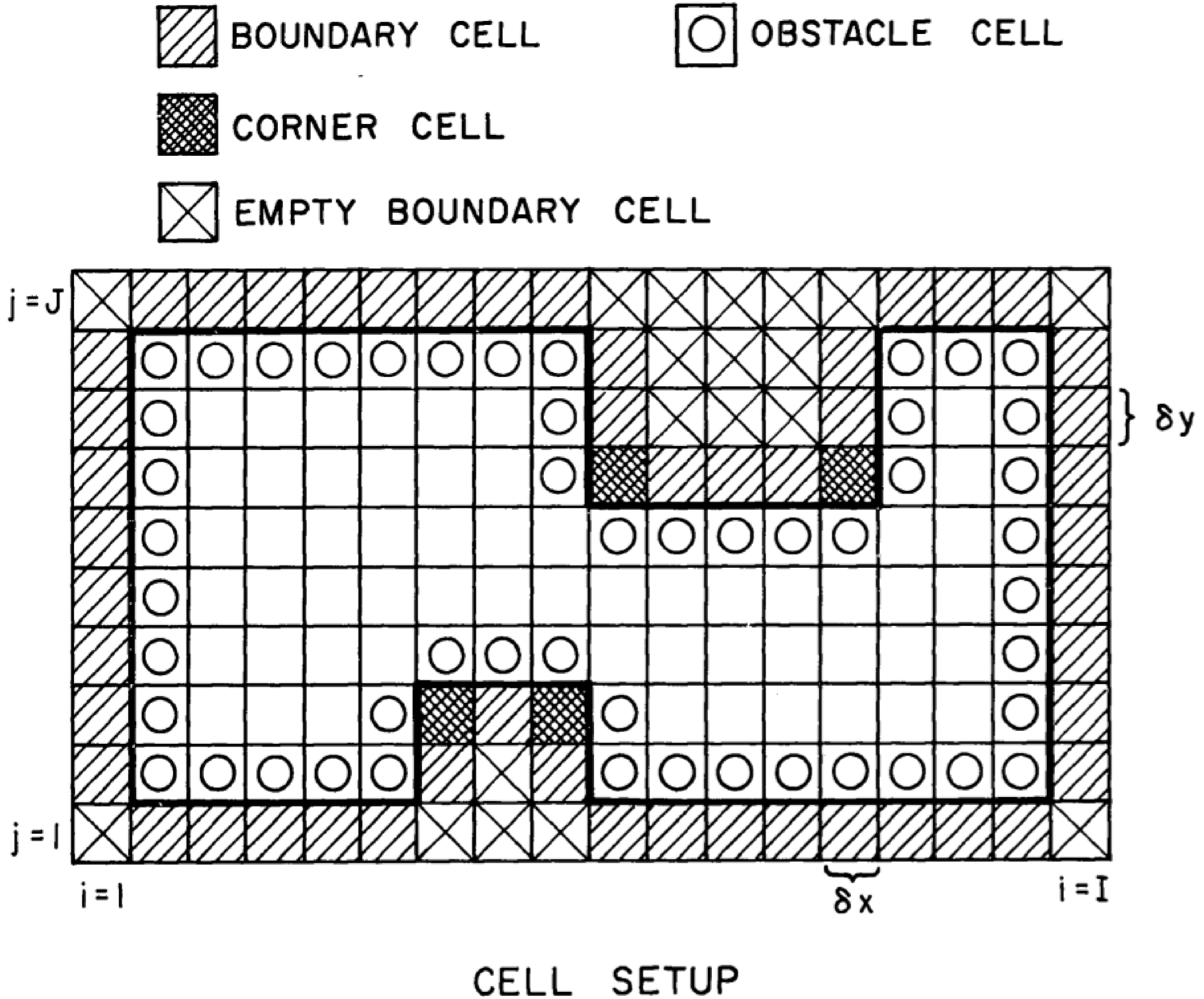


Fig. 2.2 Positions of different types of cells for a typical problem.

Wartości na siatce

For example:

$$u_{ij} = \frac{u_{i+\frac{1}{2}j} + u_{i-\frac{1}{2}j}}{2}$$

$$u_{i+\frac{1}{2}j+\frac{1}{2}} = \frac{u_{i+\frac{1}{2}j} + u_{i+\frac{1}{2}j+1}}{2}$$

$$(uv)_{i-\frac{1}{2}j-\frac{1}{2}} = \left(\frac{u_{i-\frac{1}{2}j} + u_{i-\frac{1}{2}j-1}}{2}\right)$$

$$\left(\frac{v_{ij-\frac{1}{2}} + v_{i-1j-\frac{1}{2}}}{2}\right)$$

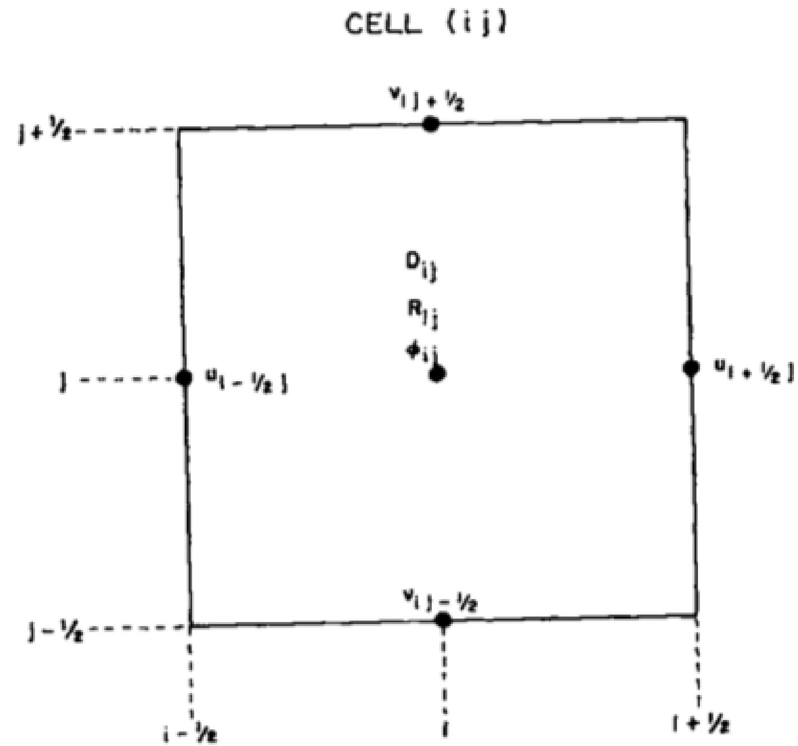
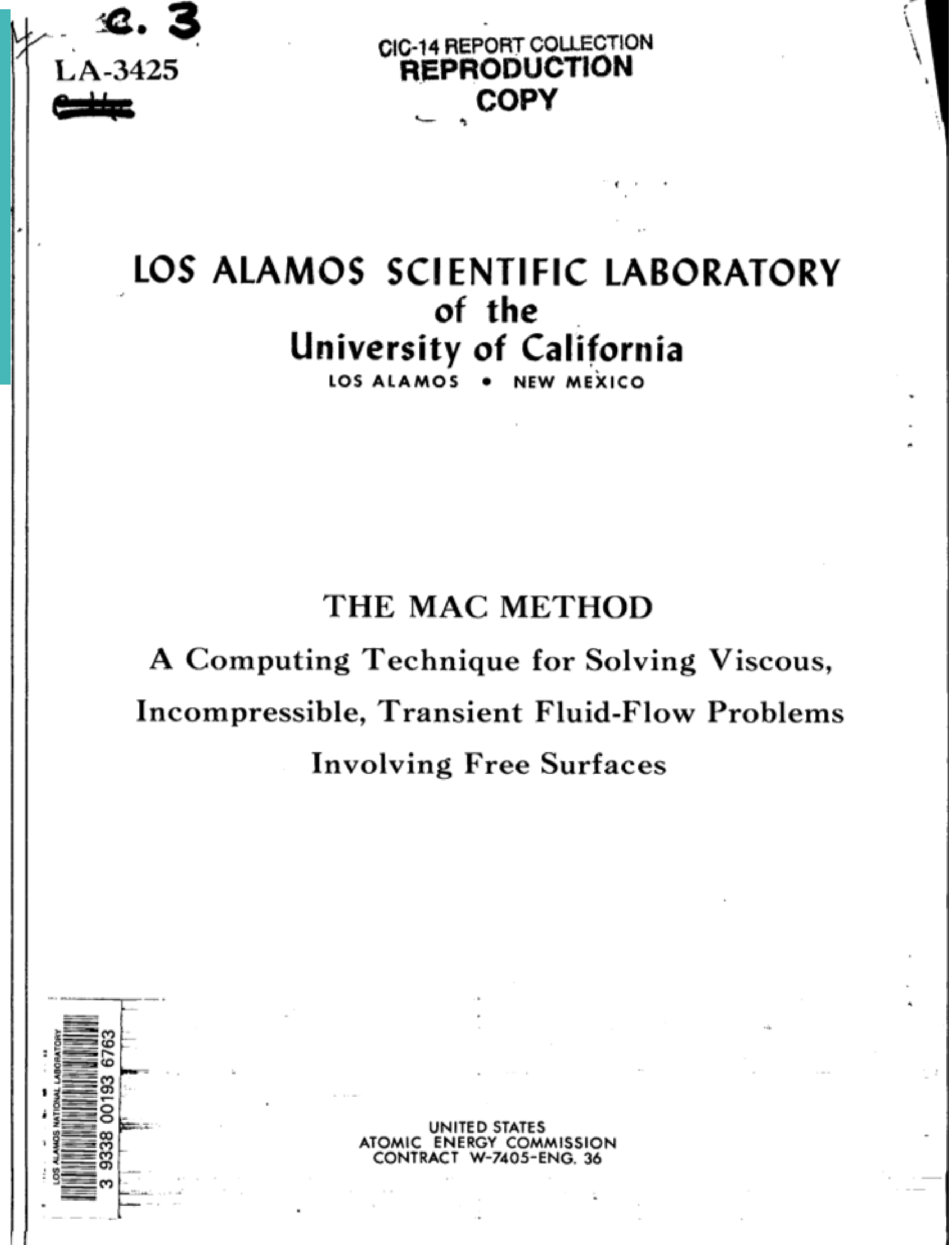


Fig. 2.3 Points of definition of variables with respect to cell.

Finite Differences (MAC)



c. 3

LA-3425

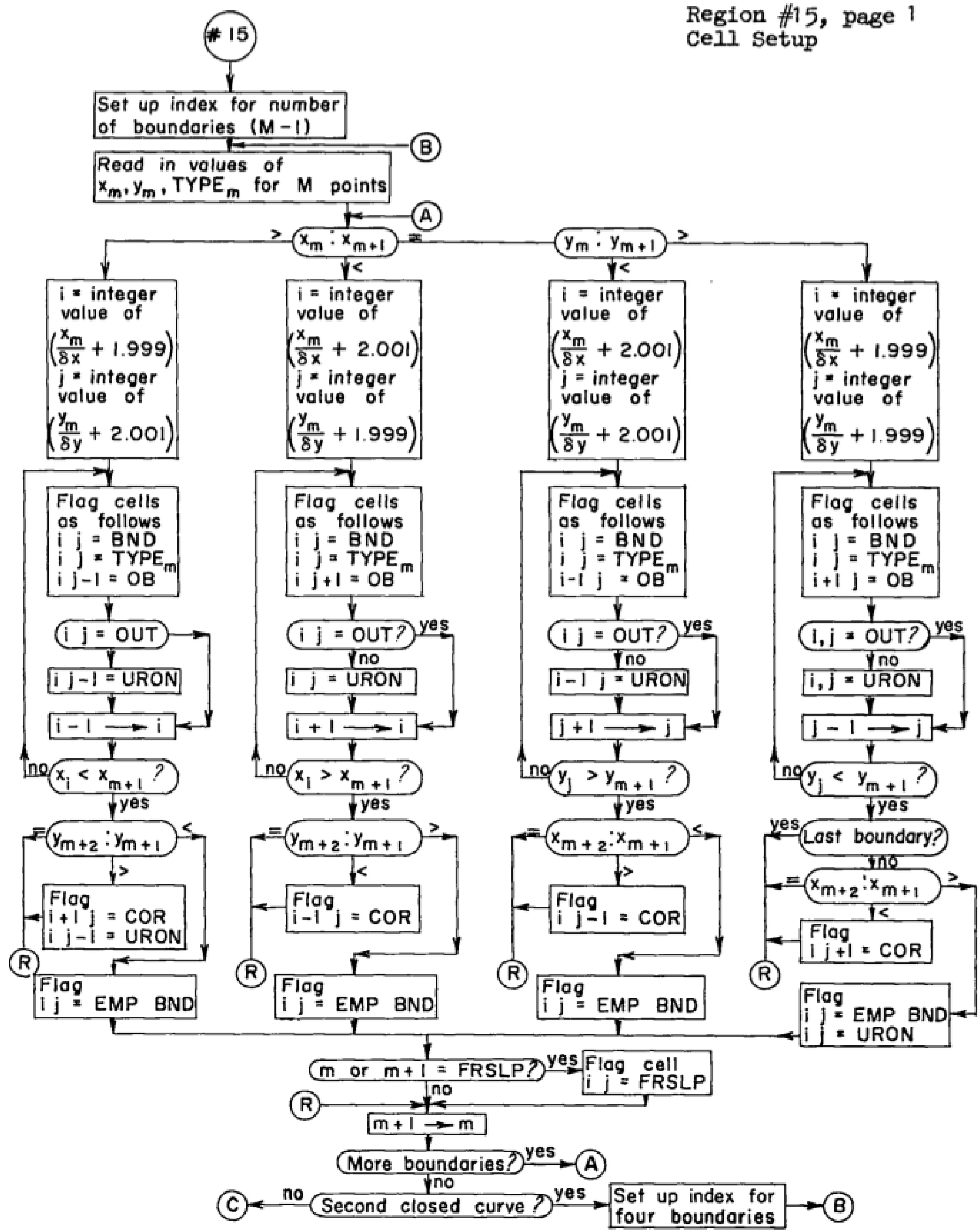
LOS ALAMOS SCIENTIFIC LABORATORY
of the
University of California
LOS ALAMOS • NEW MEXICO

THE MAC METHOD

A Computing Technique for Solving Viscous, Incompressible, Transient Fluid-Flow Problems Involving Free Surfaces

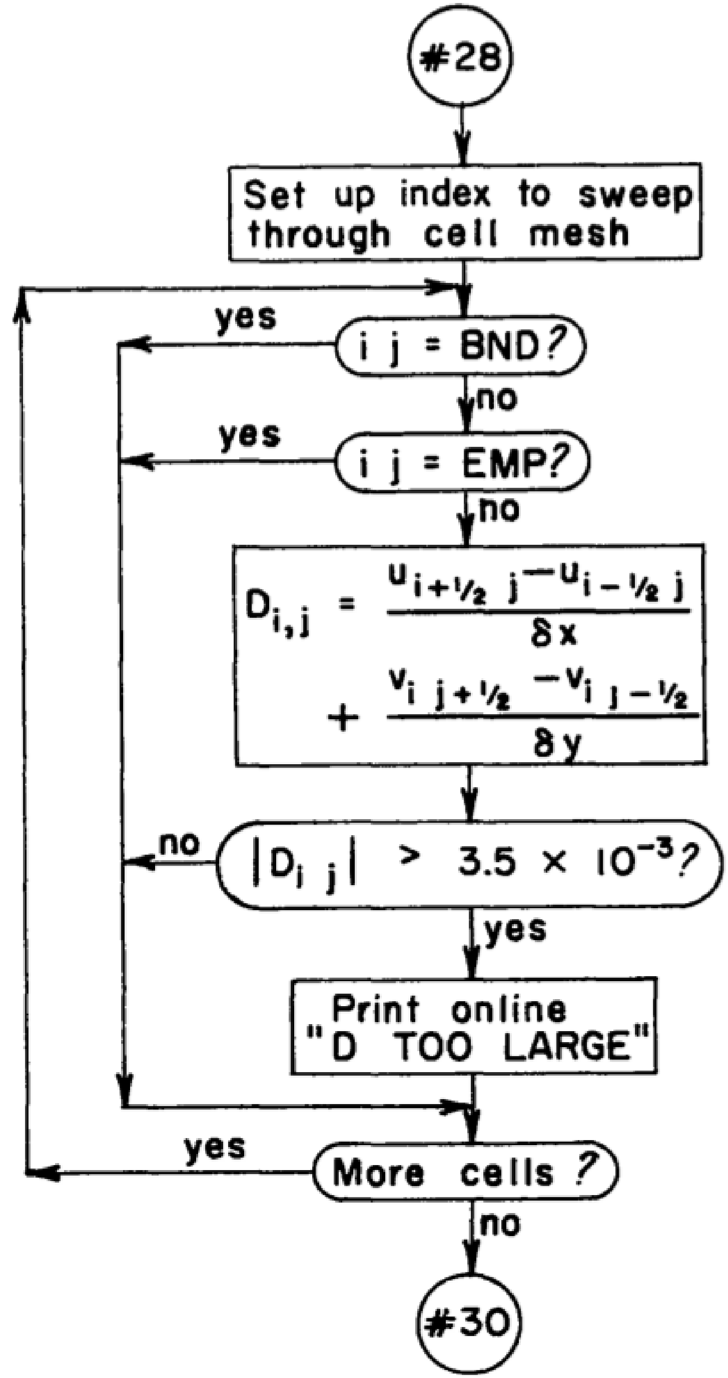
UNITED STATES
ATOMIC ENERGY COMMISSION
CONTRACT W-7405-ENG. 36

MAC Algorithm



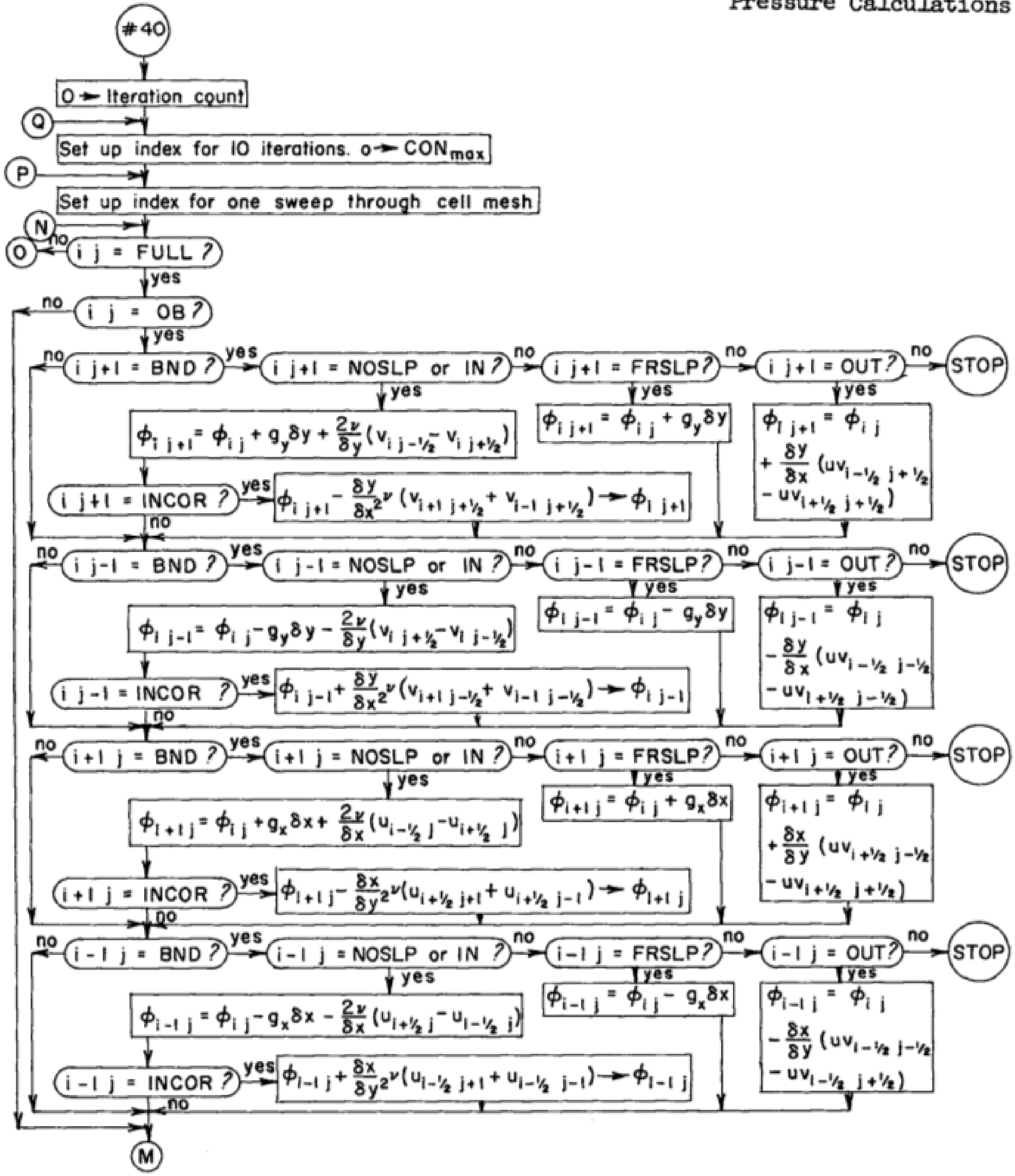
Calculation of Dij

Region #28
$D_{i\ j}$ Calculation

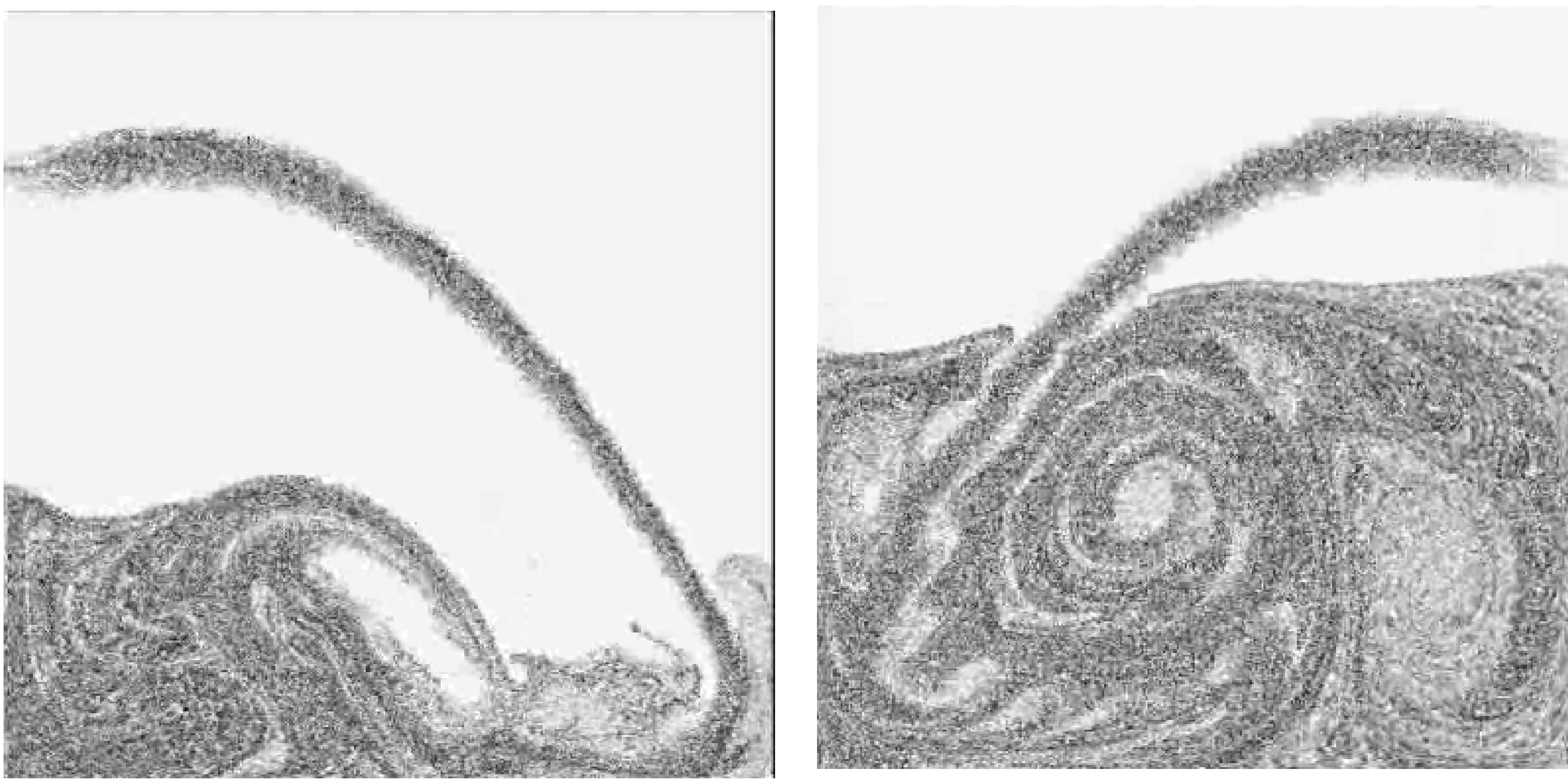


Pressure

Region #40, page 1
Pressure Calculations



Zmodyfukowana Metoda MAC



2jets (2).wmv
3.2 MB

N. Foster, R. Fedkiw (2001)

http://youtu.be/Uo2SNtFofWI

5_Shrek - All Stars.mp4

5_Shrek - All Stars.mp4
32.4 MB